NERRS Science Collaborative Progress Report for the Period 9/1/2012 through 02/28/2013

Project Title: Nitrogen Sources and Transport Pathways: Science and Management Collaboration to Reduce Nitrogen Loads in the Great Bay Estuarine Ecosystem

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Project start date: 09/01/2010

Report compiled by: William H. McDowell, Michelle Daley, Charlie French and Steve Miller

Contributing team members and their role in the project: William H. McDowell (oversees all project activities), Michelle Daley (manages field work, works collaboratively with stakeholders and is responsible for GIS analysis and data synthesis), Charlie French (science Integration Leader), Steve Miller (assists with science integration), Jody Potter (manages laboratory analyses and is responsible for caffeine and optical brightener analysis), John P. Bucci (responsible for mitochondrial (mt) DNA analysis) and Erik Hobbie (responsible for isotopic analysis of sediment)

Nitrogen Sources Collaborative-Science Advisory Board members: Members represent a diverse group of stakeholders from the Great Bay watershed including municipal planners and decision-makers, representatives of non-profit organizations, and local and regional businesses. All volunteer their time to meet, engage with the research team, learn about the research being conducted, and discuss how the research results can make a positive impact in the Great Bay watershed.

A. Progress overview: State the overall goal of your project, and briefly summarize in one or two paragraphs, what you planned to accomplish during this period and your progress on tasks for this reporting period. This overview will be made public for all reports, including confidential submissions.

Overall goal of the project: To detect non-point nitrogen sources and transport pathways in the Great Bay watershed while engaging decision makers in the science to ensure results are useful and will ultimately help reduce nitrogen loads in the Great Bay estuarine system.

Revised Project Objectives (based on stakeholder feedback described previously):

1. Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders
2. Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots"
3. Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers
4. Quantify N attenuation in large river reaches by modeling N inputs and outputs and inferring N attenuation

During this reporting period our goal was to work on objectives 1, 2 and 3. We planned to host a meeting with our Nitrogen Sources Collaborative Advisory Board (NSCAB), distribute our Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes" in conjunction with the NSCAB meeting, collect samples from intensive sties, analyze samples from both extensive and intensive sites, assess watershed characteristics for stream sites in collaboration with the New Hampshire Geological Survey (NHGS) using GIS layers developed or used by NH DES in the Great Bay Nitrogen Pollution Sources Study (GBNPSS), and begin to develop and apply landscape models that predict nitrogen concentrations based on watershed characteristics . We held an NSCAB meeting in December where we gave a project update, got feedback on potential project products and the Piscataqua Region Estuaries Partnership gave an overview of the 2013 State of Our Estuaries Report. A "Nitrogen Sources Newsbytes" newsletter was released in December which included an update on the project, a recent press release distributed by the National Science Foundation on research that links added nutrients to the reason that salt marshes are "falling apart" and locally relevant information on wastewater and stormwater. Approximately 850 of the more than 1100 extensive samples have been analyzed to assess the range of nitrogen concentrations in streams throughout the watershed and to look for nitrogen "hot spots". Intensive sites were sampled in October, November and December for tracer testing and application and preliminary isotope, mt DNA and pharmaceutical data are available. NH DES is still finalizing the draft GBNPSS report and the watershed characteristic analysis has been put on hold until this study is released so that we can use the same methodology as the GBNPSS when assessing watershed characteristics that contribute nitrogen to streams. Models that predict nitrogen concentrations based on watershed characteristics could not be fully developed or applied to our extensive sampling sites during this reporting period because additional time is needed to finish analysis of extensive samples and fully characterize our sites watersheds using GIS after the release of the GBNPSS study.

B. Working with Intended Users:

- Describe the progress on tasks related to the integration of intended users into the project for this reporting period.

Our main mechanism for integrating intended users into the research project is the Nitrogen Sources Collaborative Advisory Board (NSCAB) and distribution of the Nitrogen Newsbytes Newsletter. NSCAB members include civic leaders, community decision-makers, business owners, and others who have a stake in the Great Bay nitrogen issues and want to help ensure that good science leads to sound community decision-making. Typically quarterly NSCAB meetings are held to discuss project objectives, progress towards objectives, next steps and final products.

NSCAB Meeting December 2012: We held an NSCAB meeting in December where the integration team and science team provided an update on the project, presented more information on nitrogen sources going into the estuarine system, got feedback from NSCAB members on potential project products and the Piscataqua Region Estuaries Partnership gave an overview of the 2013 State of Our Estuaries Report. We are in the process of planning another for NSCAB meeting for April of 2013.

Nitrogen Newsbytes Newsletter: The integration team worked with the scientists to issue the Fourth Nitrogen Newsbytes newsletter in December 2012 which included an update on the project, a recent press release distributed by the National Science Foundation on research that links added nutrients to the reason that salt marshes are "falling apart" and locally relevant information on wastewater and stormwater. Through the newsletter, we have collected feedback on issues of importance to watershed stakeholders and we have shared the most up-to-date progress on the project. The list of subscribers has grown to over 110 people representing diverse interests (e.g. sewer districts, conservation and watershed organizations, taxpayers, national Senator staffers (Shaheen), etc.

Presentations to and discussions with local stakeholders and intended users on nitrogen issues in the Great Bay watershed

Daley, M.L. and McDowell, W.H. 2012. Addressing Nitrogen Issues in Great Bay – Non-Point Nitrogen Sources. Co-sponsored by the Oyster River Local Advisory Committee and the Oyster River Watershed Association. Madbury, NH. November 8, 2012.

Daley, M.L. 2012. Nitrogen in the Great Bay Watershed: Point and Nonpoint Sources (with specifics for the Lamprey River). Newmarket Community Forum on the Health of the Great Bay Estuary. Newmarket, NH. February 19, 2013.

McDowell, W.H. 2012. Groundwater and Surface Water Contamination in Suburban Basins. Active Retirement Association, Durham, NH. October 28, 2012.

- What did you learn? Have there been any unanticipated challenges or opportunities?

  Key lessons learned are:

  - Despite disagreement about the magnitude of the nitrogen problem in Great Bay, and the drivers of the problem, NSCAB members and community stakeholders want to see the science conveyed in a form that is not only understandable to the lay person, but also usable by decision-makers.
  - The NSCAB is fully engaged and deeply interested in this and other nitrogen studies. They have demonstrated through their questions that they understand the issue and that they want to be sure the work being done is trusted and used.
  - The electronic Nitrogen Newsbytes Newsletter is an excellent vehicle for getting out information as well as providing a feedback loop to get input from stakeholders on the work.
  - The is very strong interest in this Nitrogen Sources and Transport study on the part of the public, the SWA, NH DES, the UNH Stormwater Center, seacoast organizations, and other stakeholders who are not on the NSCAB.
  - Excellent input has been received about maps and other potential final products of this nitrogen sources and transport study.

- Who has been involved?

The NSCAB, Sewer District representatives, state environmental services staff, Lamprey River Watershed Association, Lamprey River Advisory Committee, Oyster River Watershed Association, Oyster River Local Advisory Committee, Trout Unlimited, Southeast Watershed Association, Newmarket Town Council and Conservation Commission, Marine Docents, US Senator Shaheen's office (via newsletter), state representatives (Spang, Borden, etc.).

- Has interaction with intended users brought about any changes to your methods for integration of intended users, the intended users involved, or your project objectives?

In earlier stages of the project, interaction with intended users greatly changed our project objectives. During this reporting period, interaction with intended users continues to shape the products that will be developed. The newsletter has been very useful for connecting with stakeholders on this project.

- How do you anticipate working with intended users in the next six months?

We will continue regularly scheduled NSCAB meetings coupled with the release of the Nitrogen Newsbytes Newsletter to solicit feedback on the project and products produced. When there are opportunities to present to interested stakeholders, this nitrogen sources and transport project team will welcome the opportunity. The integration team and science team will participate in one or more nitrogen workshops that focus on best management practices. A timeline for the next six months (Year 3, Q3 and Q4) as well as the remainder of the project can be found in Table 1.

Table 1. Revised objectives and activity timeline. Note that we will be requesting a one year no-cost extension in the next 6 months.

List Project Objectives, Products, Activities	Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1:Integration of Science with End Users								
Engage stakeholders in framing the research questions	Completed							
Utilize NSCAB to guide the science objectives and desired products	x	x	x	x	x	x	x	x
Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes"	x	x	x	x	x	x	x	x
Adapt science in the field to address stakeholder input/needs	Completed							
Stakeholder analyses and review of findings	x	x	x	x	x	x		
Develop products that are useful for decision-makers		x	x	x	x	x		
Explore publication products with stakeholders				x	x	x		
Objective 2: Identify, model and map N concentrations to identify "hot spots" – Extensive sites								
Site Designation								
Assess catchment characteristics as delineated and described by NH Geological Survey (NHGS)	Completed							
Select ~250 study sites and generate maps necessary for initial sample collection	Completed							
Revise study site locations after site visit, sample collection and analyses	Completed							
Revise maps necessary for field collection	Completed							
Field sampling and Laboratory analyses								
Collect stream samples from extensive sites	Completed							
Process and analyze stream samples from extensive sites	x	x	x	x				
Compile data for analyses of N concentrations	x	x	x	x				
Create models and maps of N concentrations and "hot spots"								
Delineate watersheds for final extensive sites and characterize attributes (land use, population density, impervious cover etc.)	x	x	x	x				
Apply Lamprey DIN vs. population density model to extensive sites	x	x	x	x				
Develop Great Bay landscape model that predict N concentrations	x	x	x	x	x			
Identify "hot spots" where N concentrations are higher than expected	x	x	x	x	x			

List Project Objectives, Products, Activities	Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Map N concentrations and "hot spots"	x	x	x	x	x			
Apply N model to NHGS catchments (~3500) and identify those at risk for high N				x	x	x		
Share available data with NHDES for accuracy assessment of nitrogen pollution source study	x	x	x	x	x	x		
Objective 3: Identify N sources in surface waters and the delivery pathway – Intensive sites								
Select ~12 study sites that represent a single N source to test tracers	Completed							
Collect source water samples from tracer testing sites and analyze N fractions	x	x	x	x	x	x		
Isotopic analysis (^{15}N , ^{18}O) of nitrate source water	x	x	x	x	x	x		
Caffeine, optical brightener and mitochondrial DNA analysis of source water	x	x	x	x	x	x		
Sediment collection and ^{15}N analysis of tracer testing sites	Completed							
Select ~8 "hot spots" study sites to apply tracers	x	x	x	x	x	x		
Collect water and sediment samples from tracer application sites during baseflow and storms	x	x	x	x	x	x		
Analyses of tracers and N fractions at tracer application sites	x	x	x	x	x	x		
Data analyses	x	x	x	x	x	x		
Prepare statistical (ongoing and final) analyses	x	x	x	x	x	x		
Objective 4: Estimate N attenuation in large river reaches								
Model N inputs and outputs and infer N attenuation					x	x	x	
Prepare Publications						x	x	x

C. Progress on project objectives for this reporting period:

- Describe progress on tasks related to project objectives for this reporting period.

Progress on **objective 1**: Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders

See section B

Progress on **objective 2**: Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots".

Approximately 850 of the more than 1100 extensive samples have been analyzed to assess the range of nitrogen concentrations in streams throughout the watershed and to look for nitrogen "hot spots". Preliminary data show that several sites exhibit median dissolved inorganic nitrogen (DIN; Figure 1), dissolved organic nitrogen (DON; Figure 2) and total dissolved nitrogen (TDN) concentrations above the 0.45 mg/L total nitrogen (TN) threshold set to protect dissolved oxygen levels in tidal rivers and the Great Bay. Maximum DIN concentrations reached 3.9 mg N/L and maximum DON concentrations reached 1.2 mg N/L. The remaining extensive samples will be analyzed over the next 6 months. We have also assessed GPS coordinates and field data from the final two extensive sampling campaigns conducted in the summer of 2012.

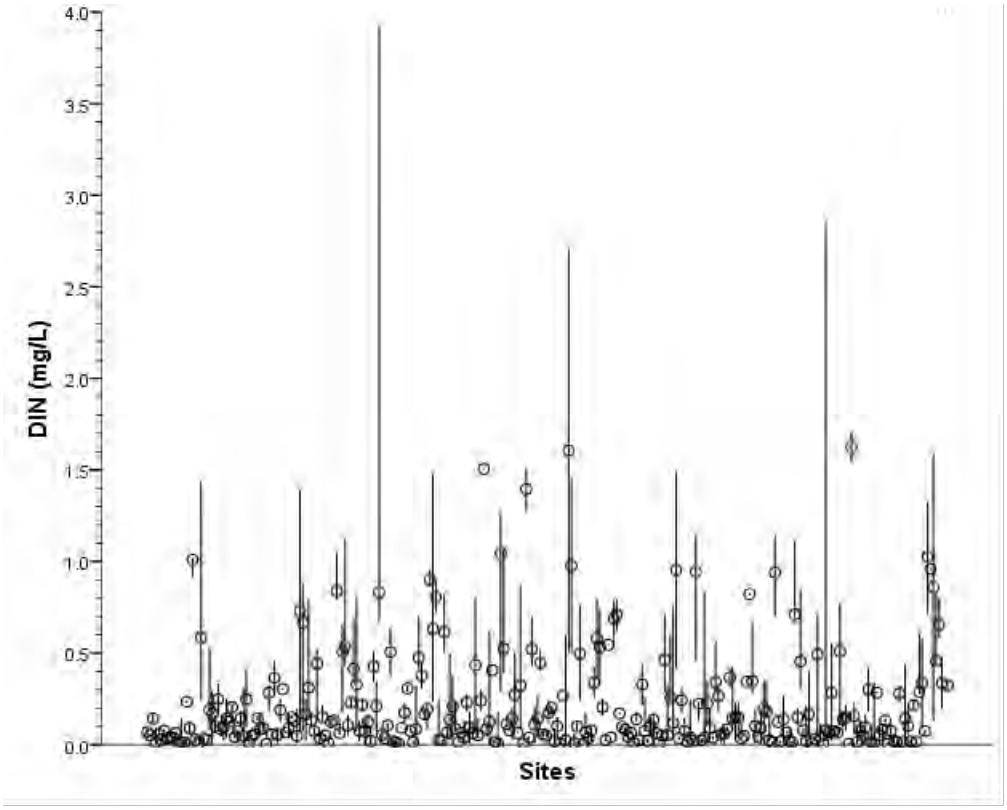

Figure 1. Dissolved inorganic nitrogen (DIN) concentrations among extensive sampling sites. Circles represent the median site value and lines represent minimum and maximum concentrations.

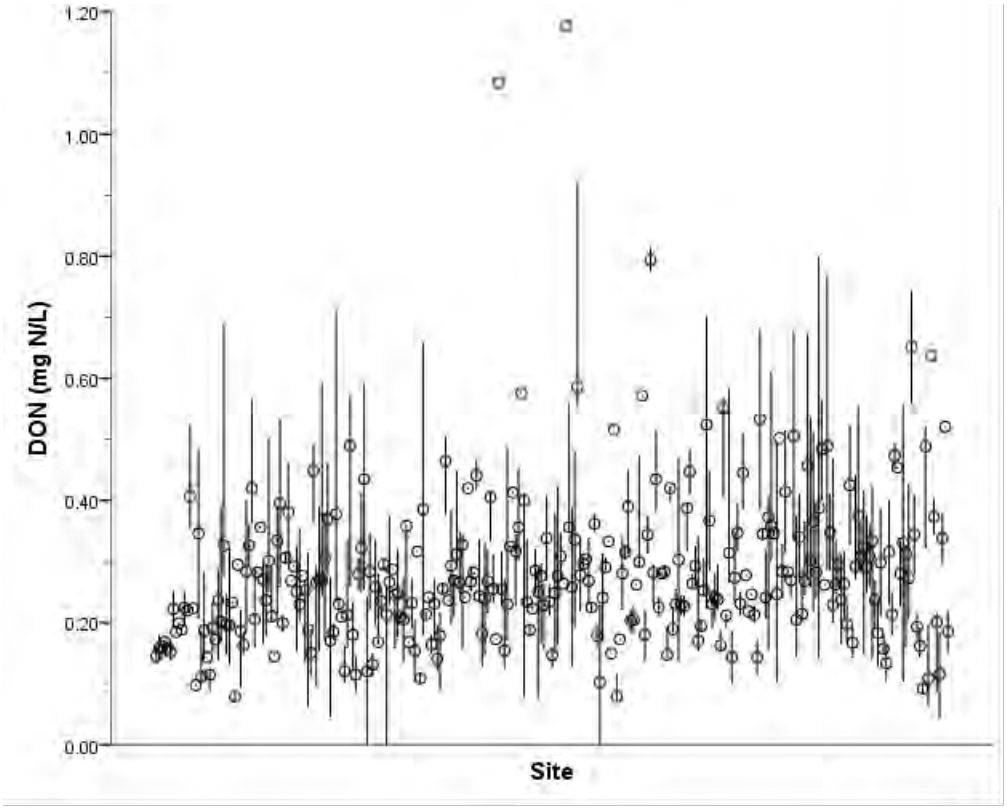

Figure 2. Dissolved organic nitrogen (DON) concentrations among extensive sampling sites. Circles represent the median site value and lines represent minimum and maximum concentrations.

NH DES is still finalizing the draft GBNPSS report and the watershed characteristic analysis in collaboration with the NHGS has been put on hold until this study is released so that we can use the same methodology as the GBNPSS when assessing watershed characteristics that contribute nitrogen to streams. Models that predict nitrogen concentrations based on watershed characteristics could not be fully developed or applied to our extensive sampling sites during this reporting period because additional time is needed to finish analysis of extensive samples and to fully characterize our site's watersheds using GIS after the release of the GBNPSS study. These tasks will begin next reporting period provided that the data layers and methods for estimating nitrogen inputs used in the GBNPSS are released with the draft report. It is important that we use these same data sources in our spatial analysis so that our results can help assess the accuracy of the GBNPSS. Once watershed characteristics have been assessed, all samples have been analyzed and models have been developed and applied to our sites, we will then be able to compare N concentrations to model predictions to further identify "hot spots" or sites that have higher (or lower) N concentrations than we would expect based on the watershed characteristics. Sites that currently exhibit relatively high N concentrations are potential "hot spot" sites.

Progress on **objective** 3 Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers.

Intensive sites were sampled in October, November and December for tracer testing and application and preliminary nitrogen concentration, isotope, pharmaceutical and mt DNA data are available. All intensive stream sites sampled in the fall exhibited nitrate concentrations that were less than 0.5 mg N/L, but groundwater concentrations were noticeably higher at a suburban (3.82 mg N/L) and agricultural site (11.2-106 mg N/L). Nitrate isotope analysis indicates that the source of nitrate at many sites is animal waste, and not from wet deposition, pavement drainage or fertilizer. One site that drains a large portion of the Pease airport strip shows an isotopic signature that is similar to pavement drainage. The high d15N-NO_3 in shallow agricultural groundwater may indicate denitrification and removal of nitrogen along the flow path.

Mitochondrial DNA analysis of August base flow samples showed a low presence of human mtDNA in two urban streams (Moonlight Brook and College Brook) and in suburban stream and groundwater (Wednesday Hill Brook). A low presence of bovine mtDNA was detected in agricultural stream water and groundwater and at one urban site (Hodgson brook). Canine mtDNA analysis indicated a low presence of canine mtDNA at two urban sites, one suburban site and a reference stream in Pawtuckaway State Park. During a storm in October, human mtDNA was not detected in an agricultural stream (BDC) or 3 suburban streams (WHB, James Farm or LMP73), but it was present in one urban stream (Moonlight Brook). Mitochondrial analysis of bovine and canine sources was not conducted on the storm samples.

A few intensive sites were sampled for pharmaceuticals in December and Hodgson Brook exhibited the highest concentrations of all pharmaceuticals except for carbamazepine among the sites (Table 2). Pharmaceuticals were detected at the other suburban (Wednesday Hill Brook) and urban (Berry, Moonlight and Gosling Brook) sites. Concentrations of pharmaceuticals in the suburban groundwater were higher than the stream water indicating that septic systems are a source of nitrogen at this site.

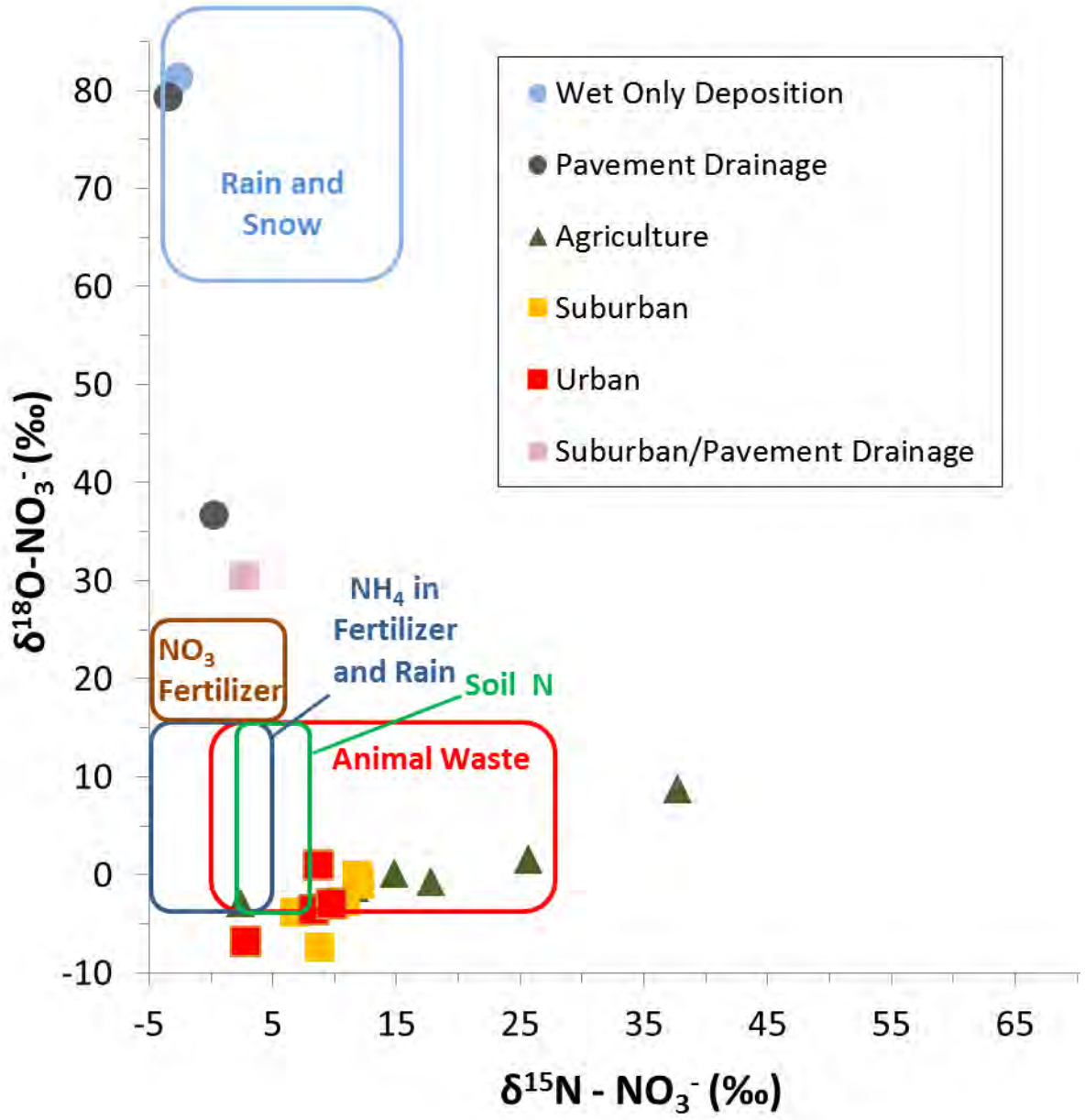

Figure 1. Nitrate isotope data from wet deposition, pavement drainage, streams (agricultural, suburban and urban) and groundwater (agricultural) sampled in the fall 2012. Boxes indicating nitrate isotope signatures were identified by Kendall 1998.

Table 2. Pharmaceutical concentrations (ng/L) at a suburban site (Wednesday Hill Brook) and urban sites (Hodgson, Berry, Moonlight and Gosling Brooks). Red values are below detection limit and orange value is below laboratory blank value.

Site	Atenolol Beta Blocker, High Blood Pressure	Acetaminophen Pain Reliever	Cotinine Metabolite of Nicotine	1,7-Dimethylxanthine Metabolite of caffeine	Caffeine Natural Stimulant	Carbamazepine Anti-depressant / bi-polar or Anti-convulsant (epilepsy)	Metoprolol Beta Blocker, High Blood Pressure
Wednesday Hill Brook	ND	ND	0.22	2.5	9.8	1.6	ND
Wednesday Hill Brook (well)	ND	ND	1.9	9.3	27	4.3	ND
Hodgson Brook (Borthwick Ave)	11	100	11	70	540	0.36	13
Berry Brook	ND	2.9	1.8	8.6	30	ND	1.4
Moonlight Brook	ND	ND	0.58	3.5	78	ND	ND
Gosling Brook	ND	ND	5.3	5.6	40	ND	ND
Reporting Limit (ng/L)	2	2	0.4	2	4	0.4	2
Daily Dose (ng)	50000000	650000000	N/A	N/A	200000000	800000000	200000000

- What data did you collect?

As described previously, we collected feedback from intended users and collected samples and field data from extensive and intensive sites.

- Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?

As we plan for a nitrogen workshop, we intend to ask NSCAB members to become more actively engaged with others in sharing the science resulting from the project. As an example, we are soliciting items for the newsletter from NSCAB members and have encouraged them to actively engage other stakeholders in discussion around the science. We feel that the NSCAB members' knowledge of the science has reached a level to enable them to not only engage in informed dialogue, but to work with constituents in their own communities to address nitrogen-related issues. At the last NSCAB meeting, we asked members if they felt comfortable engaging in a discussion about nitrogen issues and many of them felt comfortable doing so.

Significant changes to our objectives were made based on feedback from intended users and these were reported previously.

- Have there been any unanticipated challenges, opportunities, or lessons learned?

The spatial datasets that are being developed for the GBNPSS are a real asset to this project, but the release of these datasets has delayed our ability to characterize the watersheds of our sample sites. Nitrogen data from this project will help assess the accuracy of the GBNPSS and this is an important opportunity to build stakeholder trust in the GBNPSS model by providing actual on the ground data in each town.

- What are your plans for meeting project objectives for the next six months?

In the next six months we plan to work on objectives 1, 2 and 3 and perform the activities designated under Q3 and Q4 of year 3 (Table 1). These include continued collaboration with stakeholders through approximately quarterly NSCAB meetings and newsletter distribution. Watershed characteristics for extensive sites will be determined and we will analyze and compile N concentration data for extensive and intensive sites. Once watersheds are characterized in collaboration with the NHGS, we will apply models that were previously developed for the Lamprey and Oyster basins to the extensive sites to determine if previous lessons from the Lamprey and Oyster can be extrapolated to the entire Great Bay watershed. We will also then begin to develop preliminary Great Bay landscape models that predict N concentrations based on watershed characteristics. We will use the preliminary models to assess sites for N "hot spots" in greater detail. Intensive tracer testing and application sites will be sampled regularly for N concentrations and during a couple storms for tracer analysis. All available N concentration data will be shared with NHDES as it becomes useful for assessing the accuracy of the GBNPSS. This project was originally scheduled to end by 9/1/2013, but because of the additional sample collection and modeling effort for extensive

sites that was recommended by intended users as well as the delay in the GBNPSS release, we will request a one year no-cost extension during the next reporting period.

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

Conference Proceedings & Abstracts:

McDowell, W.H. 2012. Consequences of climate and land use change for ecosystems and ecosystem services in New Hampshire. Invited symposium presentation, Ecosummit, Ecological Society of America, Columbus, OH, October, 2012.

Smith, Thor E., McDowell, William H., Wollheim, Wilfred M., Daley, Michelle, Mulukutla, Gopal, Baumann, Adam J., Snyder, Lisle, and Price, Allison. 2013. Sampling the Lamprey River watershed across space and time; New data collection efforts toward understanding nitrogen sources. The Geologial Society of America Northeastern Section - 48th Annual Meeting. Omni–Mount Washington Hotel, Bretton Woods, New Hampshire. March 2013.

Press Releases

McDowell, W.H. 2012. Research Profile: Bill McDowell – Protecting Water Quality for Now and the Future. Campus Journal. University of New Hampshire. October 31, 2012.

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.